CHAPTER 1

INTRODUCTION

1.1 Background

Earth grounding system serves as lightning-protection in industrial and power plants (Liu et al., 2001). When grounding system is under fault, the system will separate the fault current to the earth by providing low resistivity path to decrease the earth potential rise at the local grounding system (Desmedt et al., 2001). Electrical conduction in rocks and soil can be divided into electronic conduction and ionic conduction where electronic conduction is the transfer of charges through a solid while ionic conduction is the transfer of ionic charges in a polar liquid such as rainwater (Laver et al., 2001). However, the current transmission is limited by the earth's resistance (PolyPhaser, 2010). Thus, it is vital to study the ground or the nature around the grounding system.

One of the major parameters to determine the performance of the grounding system is the resistivity of local soil (Dhrmadasa, 2011). Resistivity of soil varies with soil type, moisture content, temperature (Switzer, 1995), porosity, size of soil particles and so on (Fukue et al., 1999). Moisture content of soil helps the grounding electrode to disperse electrical current (Switzer, 1995). Site with low soil resistivity could install standard ground electrode system but site with high soil resistivity needs to increase the amount or diameter of grounding conductors or drive the ground electrodes deeper to achieve required ground electrode resistance. Normally, it is difficult to achieve the desired ground electrode resistance with the mentioned solutions. In these cases, ground enhancement materials or backfill material are used to enhance the grounding system to attain the required ground electrode resistance (Dale et al. 2017). A good ground enhancement material should provide low earth resistance over a long period with little variation of resistivity value (Gomes et al., 2010).

Bentonite is one of the suitable example of backfill material in decreasing and maintaining the low grounding resistance of electrodes (Lim et al., 2015) for a long time due to its high water absorption and retention tendency (Lim et al.,2013). It is a natural material that is composed predominantly of the clay mineral smectite which able to swell when in contact with free water (Keto, 2004). Bentonite is hydrate where it acts as drying agent to draw moisture from surrounding environment into its structure and holds the water chemically (Jones, 1980). According to research by Fukue et al. (1999), the resistivity for bentonite is high when water content is low. However, when the water content in bentonite is more than 40%, the resistivity is as low as 3Ωm. In Malaysia, it was reported that bentonite only deposited in several areas of Sabah such as in in Segama, Sepagaya, Mansuli and Andrassy (Samsuri, 2006). According to Malaysian Minerals Yearbook 2010, there are three bentonite processing plants in Malaysia which located one each in Perak, Johor and Selangor but the all the raw bentonite are imported. In 2010, Malaysia had imported 73,269 tonnes of bentonite mostly from India, China, USA, Australia and Germany which cost up to RM61,203,000.

Kaolinite is another type of clay which deposited in Malaysia at the state of Perak, Johor, Kelantan, Selangor, Pahang and Sarawak and around 112 million tons of kaolin have been discovered throughout the country (Baioumy et al., 2012). According to Malaysian Minerals Yearbook 2010, kaolin production in that year had increased to 530,331 tonnes from 487,632 tonnes recorded in the previous year mainly from Perak. However, kaolinite has lower plasticity behavior than bentonite. According to research by Horpibulsuk et al. (2011), bentonite has very high plasticity index which 175% is but the plasticity index for kaolin is very low which is 22%. Another study also shows that bentonite has 91.8% of plasticity index but kaolin only has 15.5% of plasticity index (Imai, 1980). Besides that, bentonite has higher optimum water content compare to kaolin due to bentonite's high sportive force from its surface electrical charges (Fattah et al., 2016). Fattah et al. (2016) state that bentonite has optimum water content up to 37% but kaolin only has 19.5% of optimum water content.

Superabsorbent polymer (SAP) is a hydrogel with three-dimensional polymer networks that expand when absorb water (Mudiyanselage et al., 2008). SAP is apply widely in several sector such as enhanced oil recovery, mine waste treatment, sludge dehydration, strengthening of concrete and soil amelioration (Gao, 2003). Gao states that

SAP improve the soil quality for plant growth by absorbing water from rainfall or irrigation and releasing it slowly. SAP able to absorb more than hundred times of water than its own weight rapidly and retain water well even at high temperature and pressure (Guan et al., 2017).

In this study, 10% of SAP are mixed with the kaolinite clay to increase the water absorption and retention behavior. Plasticity and water suction behavior of enhanced kaolinite are studied and compared with kaolinite without and with 5% SAP and bentonite. Several tests such as liquid limit, plastic limit, shrinkage limit, specific gravity, swelling index, specific surface area, loss of ignition and cation exchange capacity are carried out to determine the improvement of plasticity of kaolinite at varying percentage of SAP and soil-water characteristics curves (SWCC) are established to study the water suction behavior of kaolinite. Lastly, resistivity of kaolinite at varying percentage of SAP is determined by four point probe method and compared with bentonite which normally use as earth grounding enhancement material.

1.2 Problem Statement

Bentonite is used as earth grounding backfill material to retain the moisture content of soil and to improve grounding effectiveness by lowering the soil resistivity. However, bentonite is only deposited in several areas at east of Sabah such as in Segama, Segapaya, Mansuli and Andrassy. All the bentonites used in Malaysia are imported from foreign country. A study on replacement of bentonite to kaolinite as earth grounding backfill material is carry out as the high availability of kaolinite in Malaysia such as in the states of Perak, Johor, Kelantan, Selangor, Pahang and Sarawak. But, kaolinite has lower plasticity and resistivity than bentonite. The most significant property of bentonite is its high water absorption and retention capacity. It can absorb up to hundred times of water of its own weight. Thus, superabsorbent polymer (SAP) may be added to the kaolinite to improve its plasticity and resistivity behavior by absorbing and retaining more water.

1.3 Research Objectives

The purpose of this study is to determine the effect of superabsorbent polymer (SAP) on the water absorption, plasticity and resistivity behavior of kaolinite: